USDA – Agricultural Research Service
National Program 304 – Crop Protection and Quarantine
Action Plan 2008-2013

Introduction

U.S. agriculture provides the Nation with abundant, high quality, and reasonably-priced food and fiber. From corn and cotton, potatoes, peanuts, pumpkins, and peas to apples, alfalfa, almonds, soybeans, citrus, nuts, berries, and beans, American agriculture annually plants over a quarter of a billion acres of food and fiber crops worth over $115 billion. Additionally, agricultural commodities represent about 6 percent of the total value of all our domestic exports. Economic losses of our food and fiber due to insects, mites, and weeds, however, are considerable, with estimates in the tens of billions of dollars. Pest control includes cultural, biological, physical, and chemical methods. Non-chemical methods based on biological knowledge continue to expand, but the Nation continues to depend heavily on chemical control to produce agricultural commodities. For instance, in 2002 nearly 142 million pounds of insecticide and 400 million pounds of herbicide were applied to over 80 agricultural crops in the United States to protect these commodities from arthropod and weed pests. Maintenance of our arsenal of valuable agricultural chemicals is a constant challenge as we lose ingredients to resistance, new regulatory requirements related to public acceptance, and commercial considerations. Further, the problem of losses due to insect pests does not end in the field or with the harvest. Insects reduce the quality of stored grain and other stored products, and it is estimated that post-harvest losses to corn and wheat alone amount to as much as $2.5 billion annually. Imported commodities as well as those destined for export must be protected from native and exotic pests. Exotic insect and weed pests that threaten our food, fiber, and natural ecosystems are another mounting concern, due to the increase in world trade and travel. Invasive species such as the medfly and pink hibiscus mealybug directly threaten our agricultural crops, while other invasive insects transmit devastating bacterial and viral diseases that threaten entire agricultural industries. Still other invasive insects such as the Asian longhorned beetle and emerald ash borer decimate our forests and urban landscapes, while invasive weeds reduce biodiversity, displace native species, and cost billions of dollars to control annually.

The central challenge of National Program 304 "Crop Protection and Quarantine" will be to develop the means to mitigate the threats that native and invasive insect, mite, and weed pests pose to U.S. agriculture and our natural ecosystems.

Vision

Pest and weed management for a sustainable U.S. agriculture.

Goal

The goal of National Program 304 is to conduct fundamental and applied research that will result in improved strategies for the cost-effective management and control of native and invasive insect, mite, and weed pests, while minimizing impacts on the environment and human health. The rationale for this National Program is that the development and implementation of improved management and control strategies will contribute to maintaining the competitiveness and vitality of U.S. agriculture.

Relationship of This National Program to the ARS Strategic Plan

Outputs of Nation Program 304 research support the "Actionable Strategies" associated with performance measures from the *ARS Strategic Plan for 2006-2011*, Objective 4.2*: Reduce the Number, Severity and Distribution of Agricultural Pest and Disease Outbreaks.*

Performance Measure 4.2.3: Develop control strategies based on fundamental and applied research to reduce losses caused by plant diseases, nematodes, arthropods, and weeds that are effective and affordable while maintaining environmental quality. Develop technically and economically feasible alternatives to preplant and postharvest use of methyl bromide.

Performance Measure 4.2.4: Provide needed scientific information and technology that is environmentally acceptable to producers of agriculturally important plants in support of exclusion, early detection and eradication, control, and monitoring of invasive arthropods, weeds, nematodes, and pathogens; enhanced sustainability; and restoration of affected areas. Conduct biologically-based integrated and areawide management of key invasive species.

Performance Measure 4.2.5: Provide environmentally sound fundamental and applied scientific information and technologies to action agencies, producers, exporters, and importers of commercially important plant and animal products in support of exclusion, early detection, and eradication of quarantine pests and pathogens that can impede foreign trade.

Components

Throughout the component sections, there are links to commodity- or ecosystem-based subcomponents (Appendix I) that contain additional, in-depth information on these topics. Appendix II addresses several key issues that may play a role throughout multiple components of the Action Plan; these cross-cutting issues include areas of emerging interest such as biofuel development and climate change, as well as tools such as scientific collections, and programs such as our Overseas Biological Control Laboratories.

National Program 304 comprises four components: **Systematics and Identification; Protection of Agricultural and Horticultural Crops; Protection of Natural Ecosystems;** and **Protection of Post-Harvest Commodities and Quarantine.** Problem areas within each component address the specific concerns raised by our customers and stakeholders at a Workshop held in May 2008, as well as from additional written and verbal input critical to the airing of those concerns.

Component I. Systematics and Identification

Insects, mites, and weeds threaten plant health, our food supply, biodiversity, and global trade. There are about 2,000 invasive insects and mites in the United States, of which 373 species are considered destructive. The accurate identification of insects, mites, and weeds, whether they are native or invasive, provides important information about their possible country of origin and their bionomics and is required before the most appropriate action(s) can be determined and taken. The taxonomy and systematics of microorganisms associated with insects and weeds must also be developed so microbials can be exploited and used as biological control agents. Research outcomes from this component will trigger the rapid implementation of pest management and control strategies to either prevent the introduction of new pests or reduce their impact.

***Problem Statement IA*: *Insects and Mites*:**
Insects and mites are the most numerous and diverse groups of organisms on the planet, and the number of unknown species may exceed the number of known species. For several insect and mite taxa, identifications are not possible due to lack of expertise in the field. Since new or unknown species will likely be related genetically to species that already have agricultural impact, there is a need to examine and understand the genetic relationships among known species to provide a means to predict the potential pest status of other, related species. Research to develop classical biological control programs is a major activity of ARS. The process of identification of potential arthropod biological agents from overseas is an essential part of this work.

***Research Needs*:**
ARS will identify insects and mites for other Federal and regulatory agencies such as the USDA Animal and Plant Health Inspection Service (APHIS), the Department of Homeland Security, and State departments of agriculture, and will maintain a database of such insects and mites entering U.S. ports. To elucidate the genetic relationships between pest species and potential invasives, ARS will create original scientific treatments describing the genetic relationships among important agricultural species such as aphids, mites, termites, thrips, fruit flies, and moths, including pests of our natural ecosystems and forests. To mitigate the threat of these pests, an important additional thrust for ARS scientists will involve describing and developing genetic databases for beneficial insects, such as weed-feeders and for predators and parasitoids of pest insects, which can be used in biological control programs.

***Anticipated Products*:**

- Increased specimen representation of insect and mite species in the U.S. National Insect Collection.
- New identification tools, accurate systems of names, and predictive genetic relationships of insect and mites, including biological control agents.
- Print and electronic databases of insects, mites, host plants, geographic distributions, and vectors of plant diseases.
- Species inventories for use in conservation and management of native landscapes and natural habitats.
- Catalogs of important groups of insects and mites and online interactive identification systems.

Potential Benefits (Outcomes):

- More accurate and timely identifications of key insect and mite species for customers and stakeholders, including action agencies.
- Reduced risk of invasion from non-native insect and mite species.
- More accurate targeting of pest insects and weeds, leading to conservation of biological control agents.

Problem Statement IB: Weeds:
Noxious weeds inhabit over 100 million acres in the United States and are increasing their range by as much as 8-20 percent each year. Their economic impact is estimated to be nearly $30 billion per year. Information is needed on the proper identification of weeds, the evolutionary relationships of weeds to other plant species, and hybridization/introgression involving weed species, as well as the population structure of weed species and weed genotypes. This information is important to ensuring that weed species are efficiently and safely controlled, thereby eliminating a potential waste of economic resources that would result from directing management at the wrong target.

Research Needs:
ARS will clarify taxonomic identifications of key or newly-detected weed species and use the best available analysis methods, such as molecular phylogenetics, to determine evolutionary relationships of key weed species. Scientists will also identify and quantify the abundance of hybridization events involving key weed species and determine levels of introgression in generations following those events. Molecular analyses will be employed to determine population structure of key weed species. The origins of key weed species or weed genotypes will also be determined using existing herbarium collections, field surveys, and/or molecular analyses, so informed decisions regarding biological or other forms of control can be made.

Anticipated Products:

- Taxonomic revisions of key weed species.
- Herbarium collections of key weed species.
- Phylogenies (descriptions of evolutionary relationships) of taxonomic groups that contain key weed species.
- Descriptions of the distribution of hybridization events involving key weed species, as well as their population structure and geographic shifts.
- Knowledge of origins of key weed species or weed genotypes.

Potential Benefits (Outcomes):

- More precise knowledge of weed taxonomy.

- More rapid and efficient implementation of biological control and other weed management strategies.
- Better prediction of ecological range expansion potential of weeds.
- Species-specific control methodologies based on taxonomic relationships.

Problem Statement IC: Microbials:

The associations of microorganisms with other organisms range from mutually beneficial to parasitic and pathogenic. While insect- and weed-associated microorganisms play pivotal roles as beneficial or pathogenic organisms, the full potential of microbes as biological control agents has yet to be realized, alone or in partnership with other strategies in an integrated pest management (IPM) approach. Rapid diagnostic tests designed to differentiate species and strains of pathogens need to be developed so their potential impact on agricultural and natural resources can be assessed. In addition, new species and strains of agriculturally important microorganisms must be discovered, described and accessioned into the core ARS national culture collections. Lastly, the potential of these microorganisms as biological control agents needs to be determined and developed.

Research Needs:
New or improved methods of data analysis as well as bioinformatic tools that enhance species and strain identification will be developed. ARS scientists will also refine existing criteria and develop novel ones for the identification of species and strains from the following groups of microorganisms: insect-associated bacteria, fungi (including microsporidia), and viruses; and weed-associated bacteria, fungi, and viruses. ARS will develop rapid diagnostic tests designed to differentiate species and strains of pathogens and determine their potential impact on agricultural and natural resources. The genes and their chemical products that drive the association between agriculturally-relevant microorganisms and their host systems will be identified as will the specific factors that result in the virulence and pathogenicity of microbials used as biological control agents.

Anticipated Products:

- Improved methods for identifying microorganisms associated with insects and weeds.
- Novel and enhanced species identification and diversity databases for insect- and weed-associated microorganisms.
- Knowledge of the biotic and abiotic factors that influence the geographic dispersal of microorganisms.
- Information required by regulatory agencies for risk assessment and approval of petitions for release of biocontrol strains.
- Technology to predict biocontrol potential of new microbial strains.

- Development of molecular diagnostic assays for tracking releases of biocontrol strains.
- Technology to culture "difficult" microorganisms and microorganisms currently classified as "non-cultivable".

Potential Benefits (Outcomes):

- Reductions in crop losses due to insect pests and the diseases they may transmit.
- Distribution of microbial strains from core ARS national collections to customers, partners, and stakeholders for research and development.
- New microbial reference strains for research and industrial or commercial use.
- Accurate and confident post-release identification of pathogens approved and released for biological control.

Component I Resources:

The research needs under this component are being addressed at the following ARS locations:

Beltsville, Maryland: Systematics Entomology Laboratory

Fargo, North Dakota: Plant Science Research Unit

Fort Detrick, Maryland: Foreign Disease – Weed Science Research Unit

Ithaca, New York: Biological Integrated Pest Management Research Unit

Sidney, Montana: Pest Management Research Unit

Stoneville, Mississippi: Southern Weed Science Research Unit

Overseas Biological Control Laboratories: Office of National Programs with locations in Montpellier, France; Beijing, China; Buenos Aires, Argentina; and Brisbane, Australia.

Component II. Protection of Agricultural and Horticultural Crops

Insects, mites, and weeds have a considerable impact on our Nation's food and fiber crops, affecting domestic supply and exports with economic losses estimated to be in the tens of billions of dollars. Research outcomes from this component will directly contribute to greater productivity in traditional and organic agricultural and horticultural systems by improving and developing new, innovative control strategies, by improving existing control methods and by alerting growers and producers to problems so informed decisions regarding mitigation can be accomplished at the earliest possible time.

Problem Statement IIA: Biology and Ecology of Pests and Natural Enemies

Native and exotic insect and weed pests threaten our food and fiber and are of mounting concern. Invasive species such as the medfly directly threaten agricultural crops, while other invasive insects such as the citrus psyllid that vectors citrus greening transmit devastating bacterial and viral diseases that threaten entire agricultural industries. Native and invasive weeds pose a problem no less formidable, costing billions of dollars to control annually. A thorough understanding of the biology and ecology of arthropod and weed pests and the natural enemies (biological control agents) that may keep them in check is essential for the subsequent development of cost-effective and environmentally-safe management and control strategies.

Research Needs:
ARS will conduct research on the population ecology, population genetics, and genetic determinants of agriculturally-important pest insects and mites to uncover their host preference and specificity, their range and overwintering sites, and how they disperse and move between commodities and alternate plant hosts. The biotic and abiotic factors that impact the distribution of insect pests and their natural enemies will be determined, including a prediction of their survivability under different climatic conditions. Factors that affect the induction and termination of insect diapause will also be studied, as will the role symbionts play in the physiology and reproduction of these pests. For insect species that transmit plant pathogens, ARS will investigate the epidemiology of these interactions, including pathogen acquisition by the insect vector and subsequent pathogen development and transmission. ARS will also work to gain a better understanding of weed biology, reproduction, dispersal, and persistence and the factors affecting dormancy. Additional research is needed to determine the mechanisms of herbicide-tolerance in weeds, including resistance to glyphosate. ARS will investigate the impact of soil microbes in weed ecosystems. Finally, ARS maintains a system of Overseas Biological Control Laboratories that perform surveillance for potential biological control agents of pests and weeds, including evaluation of biology under quarantine and non-quarantine conditions.

Anticipated Products:

- Increased knowledge of the biology, ecology, behavior, and genetics of pests, biological control agents, and plant traits conferring pest resistance.
- Increased knowledge of the ecology of insect vectors of plant pathogens, including knowledge of vector and pathogen sources and dispersal into crops and disease epidemiology.
- Increased knowledge of the effects of horticultural practices on pest and beneficial populations.
- Improved understanding of how weeds respond to agroecosystem modifications, such as cover crops and rotations.
- Information on endosymbionts associated with pests and their effect on pest physiology.
- Improved monitoring systems for tracking insecticide resistance and resistance to transgenic crops.
- Increased knowledge of the underlying genetics and behavior of resistance.

- Characterization of soil and rhizosphere microbial community structure associated with perennial weed infestations and restoration practices that account for these interactions.
- Protocols for testing soil borne plant pathogenic synergists of insects released for the biological control of one or more target weed species.
- Description of the biology of pests and weeds in their native ranges in order to gain a better understanding of their damaging characteristics as invasive species.

Potential Benefits (Outcomes):

- Improved management of weed and insect pests through the use of ecologically- and economically-sound IPM strategies.
- Reduced selection pressure on insect pests and delayed development of insecticide resistance due to better understanding of pathways governing resistance.
- Improved management of companion crops for the production of bioenergy.
- Restoration of rangelands degraded by invasive species.

Problem Statement IIB*: *Control

Despite the use of a wide variety of IPM control strategies that incorporate tools such as crop rotation and the use of genetically-modified, pest-resistant crops, the use of chemical inputs for insect, mite and weed control remains high. New and improved biological and cultural control methods that are effective and environmentally sound need to be developed to reduce our reliance on synthetic pesticides. In addition, there is a need to evaluate new insecticides as they become available and determine optimum application rates. Finally, host plant resistance research plays a critical role in the protection of crops.

Research Needs:

To accurately detect and monitor insect pests (and insect biological control agents of weeds), ARS will improve sampling and surveillance methods for key species, including identifying, synthesizing, and field-testing semiochemicals. Semiochemicals such as pheromones and host-plant volatiles will also be developed as a form of control used in attract-and-kill strategies or directed at mating disruption, by interfering with host location and/or as a means of attracting beneficial insects that are parasites or predators of pest species. Research directed at the biological and cultural control of insect and weed pests will be a major ARS focus and will include the identification, evaluation, screening, and release of new biological and microbial control agents as well as the augmentation of natural enemies. New rearing methods, improved pathogen formulations, and the assessment of sterile insect release strategies will complement this research, as will foreign exploration for new agents in cooperation with the ARS Overseas Biological Control Laboratories. Additionally, scientists will assess the contribution of cultural practices such as optimized planting and mulching patterns and the use of cover crops with regard to pest suppression. Better economic thresholds comparing insect and weed density with crop yield will be developed. To enhance host plant resistance to pests, ARS will identify and characterize genes responsible for plant resistance and develop molecular markers associated with these traits. Scientists will use traditional and transgenic approaches to develop and evaluate new varieties and cultivars resistant to insect and weed pests. For short-term pest control, ARS will evaluate new insecticides and herbicides for integration into pest management systems by determining optimum application rates, frequency, and timing, and the impact of these products on pests and beneficials. As needed, ARS will also develop control strategies for non-conventional settings, such as residential areas and enclosed areas. Finally, ARS will continue to develop research protocols and cooperate in field trials for minor use registration under the IR-4 program, including the assessment of the environmental impact of all control strategies.

Anticipated Products:

- Improved pest sampling and detection methods.
- Discovery, characterization, and synthesis of insect attractants, repellents, and confusants.
- Identification and development of new biological control agents and plants with pest resistance.
- Improved methods for conservation and augmentation of mass reared biological control agents and production of applicable strategies for those methods.
- Development of economic threshold and injury levels based on quantitative relationships between pest populations and crop damage.
- Information on trap crops as potential tools for pest management.
- Facilitation of registration of novel and environmentally friendly pesticides for insect, mite and weed pests on minor crops.
- Improved resistance management systems for delaying resistance and sustaining important insecticides and transgenic technologies.

Potential Benefits (Outcomes):

- Improved management of insect pests and weeds using new IPM strategies.
- Reductions in crop losses to insect pests and the plant diseases they transmit.
- Reductions in expenditures to manage insect pests.
- Enhanced crop quality.
- Increased productivity and competitiveness of U.S. crops.

Component II Resources:

The research needs under this component are being addressed at the following ARS locations:

Ames, Iowa: Corn Insects and Crop Genetics Research Unit

Beijing, China: Sino-American Biological Control Laboratory

Beltsville, Maryland: Invasive Insect Biocontrol and Behavior Laboratory

Beltsville, Maryland: Sustainable Agricultural Systems Laboratory

Beltsville, Maryland: Sustainable Perennial Crops Laboratory

Brisbane, Australia: Australian Biological Control Laboratory

Brookings, South Dakota: Integrated Cropping Systems Research Unit

Buenos Aires, Argentina: South American Biological Control Laboratory

Byron, Georgia: Fruit and Nut Research Unit

Charleston, South Carolina: Vegetable Research Unit

College Station, Texas: Areawide Pest Management Research Unit

Columbia, Missouri: Biological Control of Insect Pests Research Unit

Columbia, Missouri: Plant Genetics Research Unit

Corvallis, Oregon: Horticultural Crops Research Unit

Fairbanks, Alaska: Subarctic Agricultural Research Unit

Fargo, North Dakota: Insect Genetics and Biochemistry Research

Fargo, North Dakota: Plant Science Research Unit

Fort Detrick, Maryland: Foreign Disease – Weed Science Research Unit

Fort Pierce, Florida: Subtropical Insects Research Unit

Gainesville, Florida: Chemistry Research Unit

Gainesville, Florida: Insect Behavior and Biocontrol Research Unit

Hilo, Hawaii: Postharvest Tropical Commodities Research Unit

Hilo, Hawaii: Tropical Plant Pest Research Unit

Ithaca, New York: Biological Integrated Pest Management Research Unit

Maricopa, Arizona: Pest Management and Biocontrol Research Unit

Montpellier, France: European Biological Control Laboratory

Newark, Delaware: Beneficial Insect Introduction Research Unit

New Orleans, Louisiana: Sugarcane Research Unit

Peoria, Illinois: Crop Bioprotection Research Unit

Shafter, California: Western Integrated Cropping Systems Research Unit

Sidney, Montana: Northern Plains Agricultural Research Laboratory

Stoneville, Mississippi: Biological Control of Pests Research Unit

Stoneville, Mississippi: Southern Insect Management Research Unit

Stoneville, Mississippi: Southern Weed Science Research Unit

Tifton, Georgia: Crop Protection and Management Research Unit

Urbana, Illinois: Invasive Weed Management Research Unit

Wapato, Washington: Fruit and Vegetable Insect Research Unit

Weslaco, Texas: Beneficial Insects Research Unit

Wooster, Ohio: Applications Technology Research Unit

Component III. Protection of Natural Ecosystems

Natural ecosystems are non-agricultural areas that include urban landscapes, forests and wetlands. They may generally consist of huge acreages and are home to many native flora and fauna. For example, the Everglades National Park in Florida encompasses 1.4 million acres of nine distinct habitats that is home to numerous animals and plants considered either threatened or endangered. Healthy natural areas are also critical to the provision of natural ecosystem services that support agriculture and that maintain a healthy environment. For example, management of invasive water-using weeds in watersheds such as the Rio Grande River Basin is critical to conservation of water resources needed for the sustainability of irrigated agriculture, riparian natural areas, and urban water users. Furthermore, natural areas share pest insects and weeds that affect agricultural crops; examples include the boll weevil, Mexican rice borer and the glassy-winged sharpshooter, a vector of Pierce's disease of grape. Research outcomes from this component will directly contribute to the prevention, management, and control of critical insect pests and weeds that threaten these environmental areas and agricultural areas bordering them.

Problem Statement IIIA*: *Insects

With the expansion of world trade, accidental introductions of exotic insects currently pose an increasing threat to our natural ecosystems. The Asian longhorned beetle is an invasive insect pest of hardwood trees (particularly maples) and over 70,000 shade trees have been removed in an effort to eradicate this pest from our urban areas. Other introduced pests such as the emerald ash borer threaten ash trees in both managed and natural forests, while an introduced scale insect has damaged trees and shrubs in many important National Parks and Refuges in Florida, including the Everglades. The gypsy moth, brought into the United States in the 1860s, is a prime example of the difficulty in controlling an introduced pest insect. From its initial introduction around Boston, the moth is now found in the entire northeastern United States, as far as Virginia and West Virginia to the south and Michigan to the west, and the U.S. Forest Service has predicted the moth will spread west and south at a rate of 21 km per year. In many instances, pesticides are not a viable option because of statutory restrictions, potential adverse effects on non-target organisms, and/or the large acreages requiring treatment. Therefore, safe, effective, biologically-based management strategies and controls need to be developed to mitigate the threats of these pest insects.

Research Needs:
For the protection of low economic-value, high environmental-value trees, efforts will focus on surveillance, monitoring and use of semiochemicals as trapping systems, the development of sterile insect technique (SIT) technologies, and especially biological control, facilitated by the ARS network of overseas biological control laboratories. ARS will discover and synthesize insect- and plant-derived chemicals that can be used as attractants to detect the movement of forest pests, and through trapping and mating disruption, slow the geographical spread of these insects. SIT will be developed for eradication of pests such as the cactus moth. Conducting overseas exploration where introduced pests are indigenous is critical to discovering natural enemies and new biological control agents. Systems will be developed for rearing these natural enemies and through host-specificity testing, ensuring their safe use. In addition, biopesticide studies with and without conventional pesticides will be carried out and ARS will conduct host plant resistance research, including hybridization studies, to identify resistant cultivars of tree species at risk.

Anticipated Products:

- Development of practical lures for use by various land managers (local, State, and Federal agencies) for detection of invasive insect pests.
- New information in the area of natural products chemistry, synthesis, and electrophysiology.
- Improved tools for studying the ecology, dispersal, and host preference of insect pests of our natural ecosystems.
- New biological control agents that restore the biological balance between exotic and native species.
- Identification of plant traits that might be used to develop pest-resistant trees.

Potential Benefits (Outcomes):

- Improved control of insect pests in natural ecosystems.
- Reductions in insect damage to trees in natural ecosystems.
- Detection of invasive species at ports of entry through improved diagnostics.
- Successful eradication of insect pests.
- Permanent biological control of introduced insect pests and weeds through the introduction of specialized natural enemies from their region of origin.
- Reductions in expenditures, including application costs, to manage insect pests.
- Native tree species (*e.g.*, ash) saved from extinction.

***Problem Statement IIIB*: Terrestrial, Aquatic, and Wetland Weeds**
Noxious weeds abound on public lands, rights-of-ways, and natural habitats throughout the United States. Most are invasive species and negatively impact these areas by displacing native species and altering entire ecosystems. Detrimental aquatic weed species occur in every conceivable natural aquatic environment, including rivers, streams, lakes, wetlands, and estuaries, and a variety of man-made systems such as canals, drainage ditches, and reservoirs. Aquatic weeds impair the normal flow and ecological functions of these habitats, reduce the abundance and diversity of native species, degrade fish and waterfowl habitat, and restrict the movement of recreational and commercial vessels. Exotic species like saltcedar, giant reed, water hyacinth, Eurasian watermilfoil, melaleuca, and the Old World climbing fern are so damaging and problematic that they, along with invasive insects and other species, helped prompt an executive order directing all Federal agencies to make the mitigation of invasive species a national priority. Of the over 100 terrestrial and aquatic plants listed on the 2006 Federal noxious weed list, the vast majority are introduced, illustrating the critical need for research to develop improved border protection strategies.

***Research Needs*:**
ARS will develop methods to control, manage, and eradicate terrestrial and aquatic weeds. To accomplish this, ARS will assess the growth of weed species relative to environmental factors and conditions (photoperiod, temperature, nutrient regimes, water use, and herbivore abundance), gain a better understanding of weed population dynamics (how they spread and disperse and interact with native plants), genotypic diversity and origin of invasive weeds, and investigate the physiological basis of dormancy. Scientists will also identify new, native and non-native biological control agents; develop mass rearing and augmentation techniques; conduct pre- and post-release efficacy evaluations; and assess their overall potential in controlling targeted weed species. This research will include determining the most effective life stage or plant part amenable for biological control. ARS will also identify candidate herbicides, and where appropriate, determine their efficacy and utility in a variety of environmental settings and how they interact with current and potential biological control agents in an effort to develop an integrated approach to weed management that is safe, selective, and efficacious. Further, scientists will determine the invasive potential of those plant species proposed for biofuel use. Research directed at aquatic and wetland weeds will focus on restoring wetland habitats that have been degraded by trees, grasses, shrubs, and creeping vines and mitigating the problems posed by submersed weeds in irrigation systems and invasive algae and plants in shellfish production systems. Finally, ARS scientists will collaborate and assist State and Federal regulatory and action agencies to integrate research findings and develop and transfer technologies for effective rapid response to eradicate newly introduced weed species.

***Anticipated Products*:**

- Increased knowledge of weed biology, population genetics, ecology and the pathways that invasive weeds use for colonization.

- Increased knowledge of the effects of invasive weeds on other species and ecosystems, enabling prioritization of control efforts.
- Discovery of new biological control agents for key invasive weeds and an increased knowledge of genomics, basic biology, and ecology of these agents.
- Discovery of new effective management tools for use in a wide range of aquatic sites such as irrigation systems, lakes, rivers, fresh water tidal systems, flood control projects and related riparian ecosystems.
- Increased knowledge of the impacts of invasive aquatic weeds on fish and waterfowl habitat functions.
- Increased knowledge of physiological and environmental controls of dormancy in highly invasive aquatic plants
- New tools for effective rapid response to newly introduced aquatic weeds.
- Improved strategies for IPM of invasive weeds in natural systems.

Potential Benefits (Outcomes):

- Reductions in economic and environmental harm to natural systems by invasive weeds.
- Restoration of degraded habitats and improvement of wildfire management on western uplands.
- Conservation of water resources.
- Contributions to the development of region-wide rapid response systems.
- Improvement in sustainable and effective weed management systems for a wide range of aquatic sites and impacted uses.
- Reduced cost of managing new infestations and reduced threat of these serving as continuing sources of dispersal.
- Reduced non-target risk through integration of biological control agents.
- Reduced cost of water conveyance for irrigation, potable, and commercial uses
- Increased coordination among Federal, State and local agencies for detection and responses to aquatic weed introductions.

Component III Resources:

The research needs under this component are being addressed at the following ARS locations:

Albany California: Exotic and Invasive Weeds Research Unit

Beijing, China: Sino-American Biological Control Laboratory

Beltsville, Maryland: Crop Systems and Global Change Research Unit

Beltsville, Maryland: Insect Biocontrol and Behavior Laboratory

Brisbane, Australia: Australian Biological Control Laboratory

Buenos Aires, Argentina: South American Biological Control Laboratory

Burns, Oregon: Range and Meadow Forage Management Research Unit

Davis, California: Exotic and Invasive Weeds Research Unit

Fargo, North Dakota: Plant Science Research Laboratory

Fairbanks, Alaska: Subarctic Agricultural Research Unit

Fort Detrick, Maryland: Foreign Disease-Weed Science Research Unit

Fort Lauderdale, Florida: Invasive Plant Research Laboratory

Gainesville, Florida: Insect Behavior and Biocontrol Research Unit

Ithaca, New York: Biological Integrated Pest Management Research Unit

Montpellier, France: European Biological Control Laboratory

Newark, Delaware: Beneficial Insects Introduction Research Laboratory

Peoria, Illinois: Crop Protection Research Unit

Sidney, Montana: Pest Management Research Unit

Stoneville, Mississippi: Southern Weed Science Research Unit

Tifton, Georgia: Crop Protection and Management Research Unit

Urbana, Illinois: Invasive Weed Management Unit

Weslaco, Texas: Beneficial Insects Research Unit

Wooster, Ohio: Application Technology Research Unit

Component IV. Protection of Post-Harvest Commodities and Quarantine

The problem of losses due to insect pests does not end in the field or with the harvest. The value of raw commodities is reduced by direct insect damage, and the detection and elimination of exotic insect pests must be accomplished to ensure the safe movement of agricultural commodities from infested to non-infested areas through marketing channels. In addition, stored grains like corn, wheat, and rice as well as nuts and fruits are processed into value-added products that are susceptible to insect attack. Research outcomes from this component will directly contribute to the development of effective and sound management strategies to reduce pest damage in post-harvest commodities, limit the spread of exotic pests within the United States, and ensure our competitiveness in the international commerce of agricultural commodities.

Problem Statement IVA*: *Insect Pests of Fresh Commodities

New exotic insect pest species that attack our fresh commodities arrive in the United States every year. Since the detection of exotic insect pests provides the foundation for subsequent exclusion, control, and eradication programs, there is a critical need for new and sensitive tools that effectively detect infestations without sole reliance on physical examination. Information on the basic biology and ecology of introduced pests is also required to determine risk and address potential threats. Additionally, there is a need to develop, assess, and implement effective, environmentally-sound, and economically-feasible systems that suppress or eradicate populations of invasive species that impact commodities while minimizing damage to these commodities and thereby maintaining market quality. Finally, the post-harvest management of diseases that cause spoilage and reduce shelf life needs to be addressed.

Research Needs:
ARS scientists will conduct research on the biology, ecology, and genetics of exotic insect pests to uncover and exploit vulnerabilities based on pest behavior, physiology or biochemistry. ARS will also develop new detection technologies for exotic insect pests that are sensitive, effective, and economically-feasible, and develop and demonstrate post-harvest treatments that meet quarantine standards. A major focus on insect pests of fresh commodities will be on fruit flies and moths and will encompass research on their basic biology, surveillance and detection, and control using chemical and biological agents, as well as SIT, with an emphasis on developing rearing strategies. Area-wide IPM approaches to reduce the economic impact of fruit flies will be developed by enhancing the role of their natural enemies and assessing the impact of new chemicals for fruit fly control. ARS will develop pre-harvest procedures to reduce the incidence of pests in boxed fruits as well as develop suitable post-harvest commodity treatments. ARS will also address and develop management practices that reduce the impact of post-harvest diseases, such as molds and rots, by discovering reduced-risk compounds and determining their efficacy under a variety of post-harvest storage scenarios.

Anticipated Products:

- Improved pest sampling and detection methods.
- Discovery, characterization, synthesis, and development of insect attractants, repellents, and confusants.
- New or improved quarantine treatments or approaches that allow safe import or export of fresh commodities.
- Increased knowledge of pest biology, ecology, behavior, genetics, and biological control agents and of plant traits conferring pest resistance.
- New biological control agents and an increased knowledge of the genomics and basic biology and ecology of these agents.
- Novel methods for reducing the impact of insect pests of fruit, vegetable, and ornamental plants.

Potential Benefits (Outcomes):

- Exclusion of exotic pest from the United States.
- New or expanded markets for U.S. fresh commodities using improved quarantine procedures.

- Increased income for U.S. producers through increased trade.
- Increased availability of fresh commodities for the consumer.
- Increased availability of suitable quarantine treatments for fruits and vegetables that meet organic labeling requirements.
- Reduced impact of IPM tactics and post-harvest quarantine treatments on the environment.
- Reduction in the use of methyl bromide and organophosphate pesticides.

***Problem Statement IVB*: Insect Pests of Durable (Stored and Processed) Commodities**
Insects are estimated to damage 5-10 percent of grain stored in the United States each year. Insecticides have historically been used for insect control in stored grain, but many of these are being lost due to insect resistance or regulatory changes. New pests are being introduced via imports from other countries, and we know little about the biology and control of these pests. Sensitive methods are needed for detecting insects in grain before the grain is placed into storage and in marketing channels, a challenging undertaking since many of the primary grain pests feed internally within kernels. Insects in processed commodities damage the reputations of food processors, since they are considered generally unacceptable to the consumer and may cause allergy or other health-related problems. Therefore, there is an urgent need to develop management and control programs for insect pests of these commodities that are practical, cost-effective, and environmentally sound.

***Research Needs*:**
ARS will develop and refine detection and monitoring methods for insects in stored and processed commodities. Specifically, scientists will develop techniques for the acoustic or electromagnetic detection of insects inside bulk stored grain and grain kernels and improve methods for monitoring insect pests in grain elevators. Also, by developing attractants and traps for grain pests, interpreting trap catches, and developing simulation models, scientists will aid in management decisions regarding treatment. Scientists will characterize the biology of emerging stored-product insects and their natural enemies to help develop new control strategies. ARS will also investigate the contribution of outdoor populations of insects to infestations as well as the locations within milling facilities that allow pest insects to avoid control treatment. ARS will evaluate conventional and organic pesticides for efficacy as these compounds become available and develop new microbial and biological control agents. Finally, scientists will conduct genomic and proteomic studies to identify physiological targets that can be exploited for stored-product insect control.

***Anticipated Products*:**

- Improved pest detection methods in grain.

- New and improved traps and attractants for stored-product insect pests and improved methods for implementation of monitoring programs and for interpreting results of trap catches.
- Optimization of use of registered conventional and organic insecticides.
- Development of computer-based pest management decision-making programs.
- Increased knowledge of pest biology, ecology, behavior, genetics, and biological control agents.
- Knowledge of the biology and control of emerging pests.
- Identification of novel physiological targets in insects for pest control through genomic and proteomic studies.

Potential Benefits (Outcomes):

- Ecologically-sound, improved management of stored-product insect pests.
- Reductions in losses to stored grains and processed commodities caused by insect pests.
- Reductions in expenditures to manage insect pests.

Component IV Resources:

The research needs under this component are being addressed at the following ARS locations:

Fort Pierce, Florida: Subtropical Insects Research Unit

Gainesville, Florida: Insect Behavior and Biocontrol Research Unit

Hilo, Hawaii: Postharvest Tropical Commodities Research Unit

Manhattan, Kansas: Biological Research Unit

Peoria, Illinois: Crop Bioprotection Research Unit